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# Software and Information Systems for Sustainability: A Systematic Literature Review of Models, Applications, and Evaluation Metrics

**Deki Saputra***
Universitas Bengkulu, Indonesia

**Eko Risdianto**
Universitas Bengkulu, Indonesia

**Mohammad Qais Rezvani**
Kurukshetra Universitty, India

**Putri Wiji Rahayu**
Universitas Bengkulu, Indonesia

*** Corresponding author:**
Deki Saputra, Universitas Bengkulu, INDONESIA. ✉dekiseluma2001@gmail.com

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**Abstract**

**Background**: The existing literature on sustainable software and information systems is fragmented, with research often siloed into specific models, applications, or evaluation metrics without a cohesive overview. This fragmentation hinders the development of a unified understanding necessary for researchers, practitioners, and policymakers to effectively implement sustainability principles.
**Aims**: This study aims to systematically analyze and synthesize research on software and information systems for sustainability. Its scope is to identify the dominant models, primary application domains, and key evaluation metrics used in the field to establish a consolidated understanding and guide future efforts.
**Methods:** A Systematic Literature Review (SLR) following PRISMA screened 314 Scopus documents (2017–2026) to 25 articles, analyzed using Biblioshiny, VOSviewer, and thematic synthesis.
**Result:** The analysis reveals a field in a consolidative phase, dominated by systematic review-based research (76%) focused on theoretical synthesis. While geographically diverse, the research centers on "sustainability" and "information systems" as core themes. A critical gap exists between conceptual frameworks and practical application, evidenced by a scarcity of empirical studies (only 4% quantitative) and the absence of standardized evaluation metrics.
**Conclusion:** This review concludes that while significant progress has been made in mapping the conceptual landscape, the field of software and information systems for sustainability must now prioritize empirical validation, the development of AI-driven systems, and the establishment of uniform measurement standards to bridge the gap between theoretical promise and tangible real-world outcomes.

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## INTRODUCTION

In the face of rapid technological advancement, global sustainability challenges have intensified, necessitating innovative approaches. Green Information and Communication Technologies (ICT) are highlighted as critical tools for enhancing environmental performance and reducing ecological footprints, particularly in developing countries where rapid urbanization affects environmental quality (Wasif et al., 2022; Xu & Wang, 2023). Software engineering is increasingly recognized for its potential to address sustainability concerns. The integration of sustainability metrics into the software development lifecycle is essential, as sustainable software engineering seeks to minimize environmental impacts while meeting user needs (Sriraman & Raghunathan, 2023; Odeyemi Olubusola et al., 2024; Fagarasan et al., 2023) Models that incorporate sustainable practices within software projects not only boost energy efficiency but also promote responsible resource usage (Rashid et al., 2021). The emergence of sustainable software meets the demand for eco-friendly practices in development. This involves methodologies like the Green Agile framework, which aligns

agile practices with environmental goals (Rashid et al., 2021). The development of such frameworks indicates a growing awareness and integration of environmental considerations into software engineering paradigms, ultimately contributing to global sustainability efforts (Sriraman & Raghunathan, 2023; Nazir et al., 2020; Odeyemi Olubusola et al., 2024).

Recent studies reflect a growing emphasis on sustainable software development (SSD), which seeks to minimize environmental impacts throughout the software lifecycle. Cojean et al., (2024) highlight the adoption of Continuous Integration/Continuous Benchmarking frameworks that ensure software correctness and sustainability by employing a thorough review process. Additionally, Akoh Atadoga et al., (2024) emphasize the transition towards energy-efficient programming languages and eco-friendly architectures, while also proposing methodologies for integrating sustainability principles into software engineering practices. Sriraman & Raghunathan, (2023) further contribute by examining capability maturity models that evaluate best practices for sustainable software development, suggesting that a systems thinking approach can significantly enhance sustainability efforts. Information systems play a pivotal role in achieving sustainability outcomes. Corbett et al., (2020) discuss how advancements in artificial intelligence can be aligned with sustainability goals through improved data management frameworks. Additionally, Calero et al., (2020) propose a multi-dimensional perspective on sustainable software, highlighting the importance of human, economic, and environmental sustainability factors. Furthermore, Ahmad Ibrahim et al., (2022) argue that sustainable software practices must focus on resource conservation and waste reduction, positioning information systems as vital enablers of sustainability. Sustainable ICT encompasses technologies and practices that contribute to environmental sustainability. Akoh Atadoga et al., (2024) describe how adopting methodologies like Agile and DevOps can enhance resource optimization in software-intensive applications. Meanwhile, Rashid et al., (2021) propose the Green-Agile Maturity Model, which integrates sustainability assessments into the software development lifecycle, underscoring the importance of aligning ICT practices with environmental goals. These contributions underline the critical role that sustainable ICT initiatives play in reducing the ecological impacts associated with digital technologies.

The existing literature on sustainable software development exhibits significant fragmentation, making it challenging to derive comprehensive insights. While multiple recent studies address various aspects of green software engineering, such as the implementation of eco-friendly practices (Hachim et al., 2023; Akoh Atadoga et al., 2024); Nazir et al., 2020), they often do not connect these insights into a cohesive framework. (Akoh Atadoga et al., 2024). Nazir et al., (2020) identify substantial gaps in covering broader systems and integrated models of sustainable software practices. This fragmentation destabilizes the understanding of how different approaches interrelate, thus limiting their collective impact on sustainability. There is a notable absence of integrated systematic literature reviews (SLRs) that offer a thorough overview of sustainable software engineering models, applications, and evaluation metrics. Although Swacha, (2022) provides a scoping review mapping sustainable software models, it does not address application contexts or evaluation metrics, creating a critical gap. Additionally, frameworks such as OntoSuSD Zada et al., (2022) present innovative methodologies for integration but lack comprehensive empirical validation metrics. Hence, an integrated SLR covering these dimensions is essential to align disparate threads of research and apply them effectively in practical contexts (Sriraman & Raghunathan, 2023; Ahmad Ibrahim et al., 2022). In summary, the literature requires a comprehensive SLR that consolidates models, applications, and evaluation metrics to strengthen the development of sustainable software engineering and drive impactful change in practice. Despite these contributions, existing studies remain limited in providing an integrated perspective that simultaneously connects sustainability models, application domains, and evaluation metrics within a single analytical framework. Most prior works focus on isolated aspects, resulting in a lack of holistic understanding and making it difficult to translate conceptual advances into practical implementation. This indicates a critical research gap in the absence of a comprehensive synthesis that bridges these interrelated dimensions.

The current landscape of research in sustainable software engineering and related fields is marked by significant fragmentation, which has led to inconsistencies in how concepts are defined and applied (Ramli et al., 2021). Ramli et al., (2021) underscore the confusion surrounding terminologies and the varying perspectives on adopting green IT, emphasizing the necessity for a cohesive framework. Establishing a unified and structured synthesis of existing research will not only clarify these concepts but also facilitate deeper understanding and navigation of the complexities inherent in sustainability initiatives. An integrated framework benefited all stakeholders involved. For researchers, it would provide foundational knowledge, revealing gaps and guiding future inquiries (Hachim et al., 2023; Sosunova et al., (2024). Practitioners in software development would utilize this synthesis to implement sustainable practices efficiently, optimizing resource usage and minimizing environmental impacts (Mir-Cerdà et al., 2023; Al-Sakkaf et al., 2021). Furthermore, policymakers would gain critical insights into effective strategies for promoting sustainability within the IT sector, allowing them to furnish regulations and support that enhances overall eco-friendliness while fostering technological innovation (Trang, 2021; Ghouri et al., 2024). Thus, the proposed unified synthesis significantly enriches the discourse on sustainable practices in technology and supports the establishment of a more sustainable future.

The primary aim of this study is to systematically analyze and synthesize research on software and information systems geared towards promoting sustainability. By identifying dominant models, application domains, and evaluation approaches, this study seeks to establish a consolidated understanding of how these systems can contribute to sustainability efforts. Identifying dominant models is essential because various frameworks have emerged within the field that address sustainability in different contexts. For example, Barišić et al., (2025) conduct a systematic mapping study on modeling sustainability in cyber-physical systems, emphasizing the necessity for structured frameworks in this area. Furthermore, incorporating multicriteria decision-making approaches, as suggested by Sun et al., (2021), may aid in creating robust models tailored to address specific sustainability challenges in software development. Understanding the diverse application domains is crucial for applying sustainable practices effectively. As shown by Ahmad et al., (2021), software engineering practices can significantly enhance the sustainability of Internet of Things (IoT)-driven applications. In parallel, frameworks addressing the sustainability assessment in specific domains are becoming vital, as illustrated by Anbarkhan's use of the GREENSOFT Model, which encompasses the entire product life cycle (Anbarkhan, 2023). Equally important is the identification of effective evaluation metrics that gauge the sustainability of software systems. Several frameworks exist that assess environmental impacts and performance, as discussed by Sosunova et al., (2024) and (Alajlan & Baslyman, 2023). By analyzing these approaches, the study aims to consolidate evaluation practices to guide software engineers and policymakers in implementing sustainable solutions.

This study offers a novel contribution by providing an integrated synthesis that simultaneously examines sustainability models, application domains, and evaluation metrics within a unified framework. Unlike prior studies that address these aspects separately, this research combines bibliometric analysis and thematic synthesis to deliver a more comprehensive and structured understanding of the field. This integrated approach not only clarifies conceptual relationships but also supports the development of practical and evidence-based sustainability strategies in software and information systems. In summary, this study intends to synthesize existing research comprehensively, focusing on models, application domains, and evaluation methods to enhance the effectiveness of software systems in promoting sustainability.

## METHOD

Research Design:
The method used in this study is a **Systematic Literature Review (SLR)** following the PRISMA guidelines. The study entitled *"Software and Information Systems for Sustainability: A Systematic Literature Review of Models, Applications, and Evaluation Metrics"* applies a systematic search strategy based on Boolean operators to collect relevant literature data. All data were retrieved from

the Scopus database, limited to English-language articles published between 2017 and 2026. The search was conducted in the TITLE-ABS-KEY field using the following string:

("software engineering" OR "information system") AND (sustainability) AND ("systematic literature review" OR "systematic review" OR "mapping study").

The search results from Scopus were downloaded in CSV format. If the search was conducted in multiple stages or keyword combinations, all CSV files were merged into a single ZIP file to facilitate data management. The ZIP file was then extracted and processed using OpenRefine to clean the data from duplicates, metadata inconsistencies, and potential bias.

The cleaned dataset was analyzed using Biblioshiny, the visual interface of the bibliometrix package in R. Bibliometric analysis was conducted to obtain information such as keyword metadata (DE), main dataset information, annual publication growth trends, yearly citations, most relevant sources, author productivity, corresponding author country distribution, and country-based scientific contribution mapping. Bradford's Law analysis was also performed to identify core publication sources and Sources' Local Impact.

To strengthen visualization of bibliographic relationships, the data were additionally analyzed using VOSviewer, producing Network and Overlay visualizations that reveal relationships among keywords, authors, and documents. Article selection followed the PRISMA stages: identification, screening, eligibility, and inclusion. Irrelevant articles were excluded based on predefined inclusion and exclusion criteria. Figure 1 presents the SLR methodological flow diagram used in this study.

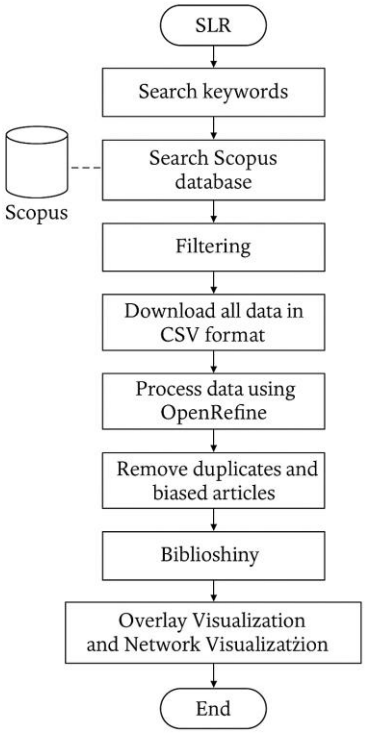



**Figure 1.** Research Method Flowchart

PRISMA Method

This study also applies the PRISMA method to describe the article selection process in a systematic, transparent, and structured manner. Through this approach, the stages of literature selection are presented sequentially, starting from identification, screening, and finally determining studies that meet the inclusion criteria. The PRISMA diagram plays an important role in ensuring that the search and selection of references are conducted validly, minimizing data duplication, and providing clarity to readers regarding each stage undertaken in compiling the literature review. The steps of the PRISMA method are illustrated in Figure 2.

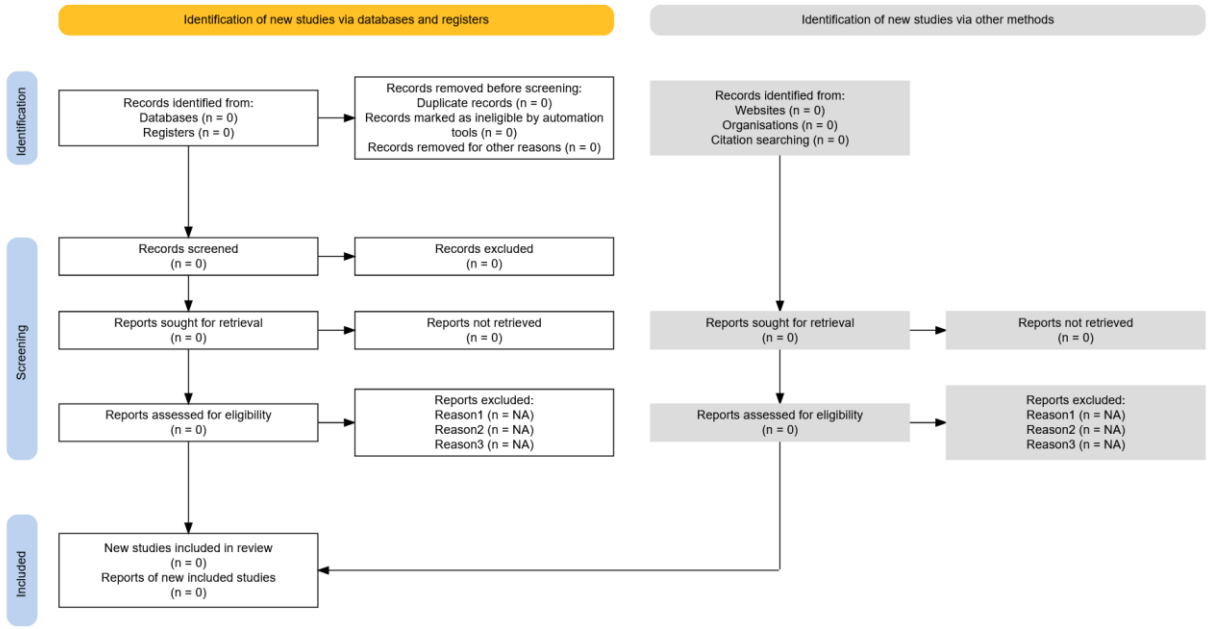



**Figure 2**. Prisma Method Diagram

## RESULTS AND DISCUSSION

### Results:

Bibliometrix Analysis

In the bibliometric analysis, the search strategy utilized the Scopus database as the primary data source related to the research theme, *Software and Information Systems for Sustainability*. Several keyword combinations were employed, resulting in five main keyword groups covering broad searches on sustainable software engineering, information systems for sustainability, sustainable ICT, sustainability evaluation metrics, and systematic reviews in this field.

For the broad search on sustainable software engineering, the following query was used:
("Software Engineering" AND "Sustainability")
The initial data obtained were later combined with other search results in a single metadata export process from Scopus.

For searches related to information systems for sustainability:
("Information System" AND "Sustainability")
The retrieved data included articles discussing the role of information systems in supporting sustainability practices and policies.

To focus on sustainable ICT and green computing:
("Sustainable ICT" OR "Green ICT")
The initial results covered studies reviewing environmentally friendly information technologies and energy efficiency in digital systems.

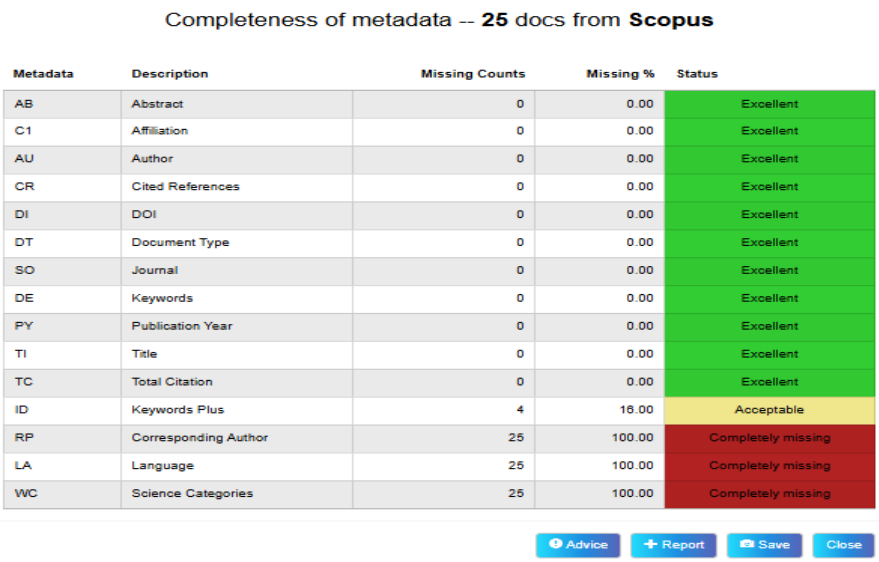
For sustainability metrics and evaluation:
("Sustainability Metrics" OR "Evaluation Metrics") AND ("Software" OR "Information System")
The retrieved articles addressed measurement and evaluation of environmental, social, and economic aspects in software and information systems.

For the integrative search incorporating systematic review approaches:
("Software Engineering" OR "Information System") AND "Sustainability" AND ("Systematic Literature Review" OR "Systematic Review" OR "Mapping Study")
This query narrowed the results to structured literature reviews within the field.

From all search combinations, a total of 314 documents were identified at the initial stage. After applying inclusion and exclusion criteria—topic relevance, document type, English language, and publication period (2017–2026)—25 articles met the final criteria. All records were exported in CSV format from Scopus, compressed into a single ZIP file for efficient data management, extracted, and processed using OpenRefine for data cleaning before further bibliometric analysis using Bibliometrix/Biblioshiny.

Data Reduction and Duplicate Removal

Using the keyword search results exported from Scopus and compressed into a single ZIP file, the data were imported into OpenRefine for filtering and metadata cleaning. This tool was used to identify potential duplicates based on article titles, standardize variations in author names, normalize keywords, and remove incomplete or irrelevant metadata entries. Based on the cleaning process and re-verification of the inclusion and exclusion criteria, the final valid dataset consisted of 25 articles. This number is consistent with the final selection obtained after filtering the initial 314 documents identified in the early stage. The cleaned dataset was then analyzed using Biblioshiny (the interface of the bibliometrix package in R) to obtain information related to metadata completeness, annual publication trends, most relevant sources, author productivity, and the distribution of scientific contributions by country. Furthermore, network visualization and relationships among keywords were analyzed using VOSviewer to identify thematic linkages, research clusters, and research development patterns in the field of software and information systems for sustainability.


Completeness of metadata -- **25** docs from **Scopus**

| Metadata | Description | Missing Counts | Missing % | Status |
|---|---|---|---|---|
| AB | Abstract | 0 | 0.00 | Excellent |
| C1 | Affiliation | 0 | 0.00 | Excellent |
| AU | Author | 0 | 0.00 | Excellent |
| CR | Cited References | 0 | 0.00 | Excellent |
| DI | DOI | 0 | 0.00 | Excellent |
| DT | Document Type | 0 | 0.00 | Excellent |
| SO | Journal | 0 | 0.00 | Excellent |
| DE | Keywords | 0 | 0.00 | Excellent |
| PY | Publication Year | 0 | 0.00 | Excellent |
| TI | Title | 0 | 0.00 | Excellent |
| TC | Total Citation | 0 | 0.00 | Excellent |
| ID | Keywords Plus | 4 | 16.00 | Acceptable |
| RP | Corresponding Author | 25 | 100.00 | Completely missing |
| LA | Language | 25 | 100.00 | Completely missing |
| WC | Science Categories | 25 | 100.00 | Completely missing |

Advice Report Save Close

**Figure 3**. Metadata on E/Keyword is good.

After the data were cleaned from duplicates and potential bias, the bibliometric data interpretation process was conducted using Biblioshiny. The overall main information of the retrieved articles is presented in the table.

**Table 1**. Key Information On the data sheet.

| Description | Results |
|---|---|
| MAIN INFORMATION ABOUT DATA | |
| Timespan | 2017:2026 |
| Sources (Journals, Books, etc) | 19 |
| Documents | 25 |
| Annual Growth Rate % | -7.41 |
| Document Average Age | 3.72 |

| Description | Results |
|---|---|
| Average citations per doc | 16.52 |
| References | 243 |
| DOCUMENT CONTENTS | |
| Keywords Plus (ID) | 244 |
| Author's Keywords (DE) | 122 |
| AUTHORS | |
| Authors | 85 |
| Authors of single-authored docs | 1 |
| AUTHORS COLLABORATION | |
| Single-authored docs | 1 |
| Co-Authors per Doc | 3.4 |
| lnternational co-authorships % | 36 |
| DOCUMENT TYPES | |
| article | 25 |

Based on the Bibliometrix analysis, the research dataset consists of 25 documents published between 2017 and 2026 and distributed across 19 different sources (journals, books, and other outlets). This indicates that the topic of circular economy in sustainable engineering remains dispersed across various publication venues and has not yet been fully concentrated in a specific core journal. The annual publication growth rate is recorded at -7.41%, suggesting fluctuations or a recent declining trend in the number of publications. The average document age is 3.72 years, indicating that the analyzed articles are relatively recent. The average citations per document are 16.52, reflecting a reasonably strong scientific impact within this field. Overall, the 25 documents involve 85 authors, with an average of 3.4 authors per document. Only one document was single-authored, while the international collaboration rate reached 36%, demonstrating a fairly strong level of research collaboration. In terms of content, the dataset includes 244 Keywords Plus and 122 Author's Keywords, highlighting both the breadth of referenced concepts and the diversity of thematic focus within the analyzed studies. All documents in the dataset are classified as research articles (25 documents), indicating that publications on this topic are predominantly scientific research articles that have actively developed in recent years.

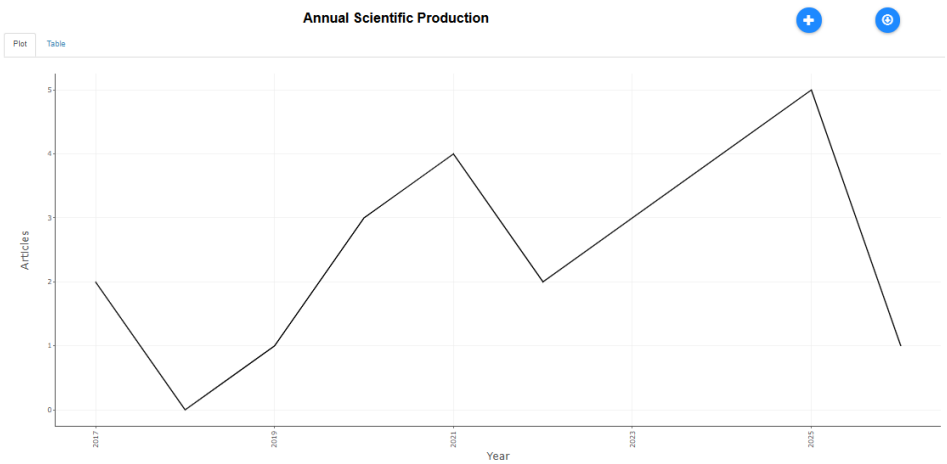



**Figure 4**. Growth Chart Every Year.

Based on the Annual Scientific Production graph, the number of publications on the analyzed topic fluctuated during the period 2017–2026. In 2017, there were 2 articles, followed by a decline to 0 publications in 2018. In 2019, the number increased to 1 article and gradually rose to 3 articles in 2020 and 4 articles in 2021. However, in 2022 the number decreased to 2 articles. The trend then increased again, with 3 articles in 2023 and 4 articles in 2024, reaching its peak in 2025 with 5 articles. In 2026, the number of publications dropped again to 1 article. This pattern indicates that research interest in the topic has generally grown gradually since 2019 and reached its highest point in 2025, although several fluctuations occurred during the period. The decrease in 2026 is likely influenced by indexing time limitations or because the year has not yet been fully completed.

**Table 2**. Growth Chart Every Year.

| Year | Articles |
|---|---|
| 2017 | 2 |
| 2018 | 0 |
| 2019 | 1 |
| 2020 | 3 |
| 2021 | 4 |
| 2022 | 2 |
| 2023 | 3 |
| 2024 | 4 |
| 2025 | 5 |
| 2026 | 1 |

Based on the Annual Scientific Production table, the number of publications during the 2017–2026 period shows a fluctuating pattern. In 2017, there were 2 articles, followed by a decline to 0 publications in 2018. The number increased to 1 article in 2019 and continued to rise to 3 articles in 2020 and 4 articles in 2021. In 2022, the number decreased to 2 articles, then increased again to 3 articles in 2023 and 4 articles in 2024. The peak of publication output occurred in 2025 with 5 articles. However, in 2026, the number of publications declined again to 1 article. Overall, these data indicate that research productivity showed a gradual upward trend from 2019 and reached its highest point in 2025, despite several fluctuations during the period, before experiencing another decline in the final year.

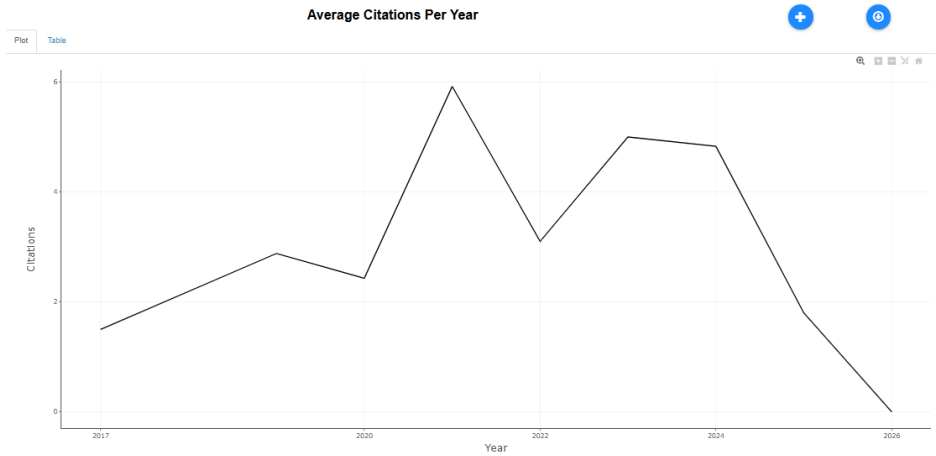



**Figure 5**. Annual Citation Graph.

Based on the Average Citations Per Year graph, the average yearly citations show a fluctuating pattern throughout the 2017–2026 period. In 2017, the average citation rate was around 1.5 and

gradually increased to approximately 2.8 in 2019, before slightly declining in 2020. The peak occurred in 2021, reaching nearly 6 citations per year. In 2022, the average decreased to about 3 citations, then rose again in 2023 to around 5 citations and remained relatively stable in 2024. However, in 2025 the average citation dropped sharply to below 2 citations, and in 2026 it approached zero. This pattern indicates that articles published between 2021 and 2024 achieved relatively high citation impact, while the decline in the most recent years is likely influenced by the recency effect, as newly published articles have not yet had sufficient time to accumulate citations optimally.

**Table 3**. Citations Per Year

| Year | MeanTCperArt | N | MeanTCperYear | CitableYears |
|---|---|---|---|---|
| 2017 | 15.00 | 2 | 1.50 | 10 |
| 2019 | 23.00 | 1 | 2.88 | 8 |
| 2020 | 17.00 | 3 | 2.43 | 7 |
| 2021 | 35.50 | 4 | 5.92 | 6 |
| 2022 | 15.50 | 2 | 3.10 | 5 |
| 2023 | 20.00 | 3 | 5.00 | 4 |
| 2024 | 14.50 | 4 | 4.83 | 3 |
| 2025 | 3.60 | 5 | 1.80 | 2 |
| 2026 | 0.00 | 1 | 0.00 | 1 |

Based on the Average Citations Per Year table, articles published in 2021 have the highest average citations per article (MeanTCperArt), reaching 35.50, with an average of 5.92 citations per year (MeanTCperYear) and a citation window (CitableYears) of 6 years, indicating the strongest scientific impact compared to other years. In 2022, the average citations per article were 15.50 with an average of 3.10 citations per year and a citation window of 5 years. The year 2023 shows an increase again, with a MeanTCperArt of 20.00 and MeanTCperYear of 5.00 over a citation window of 4 years. Meanwhile, in 2024 the average citations per article were 14.50 with an average of 4.83 citations per year and a citation window of 3 years. In 2025, a significant decline occurred with a MeanTCperArt of 3.60 and MeanTCperYear of 1.80 over a citation window of 2 years. For 2026, the published articles have not yet received citations (0.00) and only have a citation window of 1 year. These data indicate that the longer an article has been published, the greater its opportunity to accumulate citations. Therefore, differences in citation values across years reflect publication age effects rather than research quality alone.

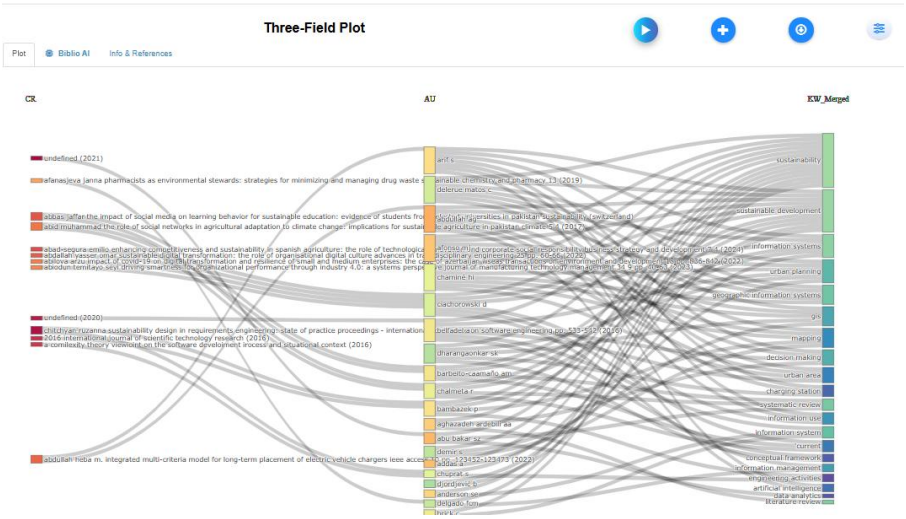



**Figure 6**. Three-Field Plot diagram.

Based on the Three-Field Plot visualization, the relationships among cited references (CR), authors (AU), and merged keywords (KW_Merged) can be observed in the analyzed studies. On the reference side (CR), several frequently cited works include publications from 2021 and 2020, as well as articles discussing sustainable education, circular adaptation to climate change, urban sustainability, long-term placement of electric vehicle chargers, and software system development. This indicates that the theoretical foundation of the dataset does not focus solely on environmental aspects but also incorporates urban planning, information systems, and technology perspectives. From the author perspective (AU), a number of authors are connected to multiple references and topics, demonstrating relatively broad collaboration patterns. Some authors act as bridges across themes such as information systems, urban planning, and sustainability, reflecting the multidisciplinary nature of the research field. Meanwhile, on the keyword side (KW_Merged), the most prominent topics include sustainability, sustainable development, geographic information systems, urban planning, GIS, mapping, decision-making, charging stations, systematic review, information systems, conceptual frameworks, artificial intelligence, and literature review. The interconnection among these three fields suggests that the research in this dataset mainly emphasizes the integration of sustainability, spatial planning, and information systems including the use of GIS and intelligent technologies rather than focusing exclusively on life-cycle analysis or waste management. Therefore, the research direction tends to evolve toward technology- and system-based approaches to support sustainable development.

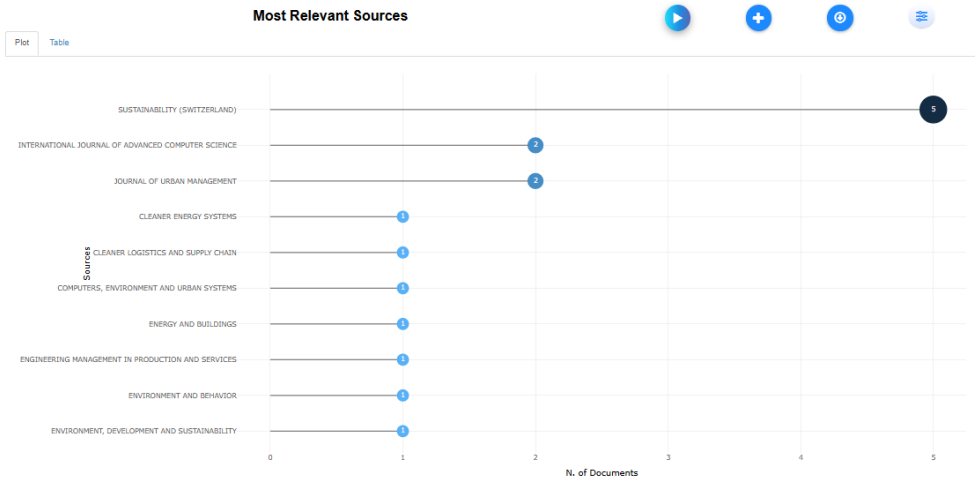



**Figure 7**. Most relevan Source.

Based on the Most Relevant Sources graph, the journal Sustainability (Switzerland) appears as the most dominant source with 5 published articles. This is followed by International Journal of Advanced Computer Science and Journal of Urban Management, each contributing 2 articles.

Meanwhile, several other journals each published 1 article, including Cleaner Energy Systems, Cleaner Logistics and Supply Chain, Computers, Environment and Urban Systems, Energy and Buildings, Engineering Management in Production and Services, Environment and Behavior, and Environment, Development and Sustainability. These findings indicate that although one journal is relatively more dominant, publications on the analyzed topic are generally distributed across multiple cross-disciplinary journals. This suggests that the reviewed studies are multidisciplinary in nature, covering sustainability, information systems, management, energy, and urban and environmental planning aspects.

**Table 4.** Sources' Local Impact

| Source | h_index | g_index | m_index | TC | NP | PY_start |
|---|---|---|---|---|---|---|
| Sustainability (Switzerland) | 5 | 5 | 0.174 | 121 | 5 | 2020 |
| Journal Of Urban Management | 2 | 2 | 0.500 | 18 | 2 | 2023 |
| Cleaner Logistics And Supply Chain | 1 | 1 | 0.200 | 25 | 1 | 2022 |
| Computers, Environment And Urban Systems | 1 | 1 | 0.250 | 31 | 1 | 2023 |
| Energy And Buildings | 1 | 1 | 0.500 | 1 | 1 | 2025 |
| Environment And Behavior | 1 | 1 | 0.167 | 49 | 1 | 2021 |
| Environment, Development And Sustainability | 1 | 1 | 0.333 | 10 | 1 | 2024 |
| Environmental Earth Sciences | 1 | 1 | 0.125 | 23 | 1 | 2019 |
| European Transport Research Review | 1 | 1 | 0.100 | 28 | 1 | 2017 |
| Globalization And Health | 1 | 1 | 0.100 | 4 | 1 | 2017 |

Based on the source analysis table, the journal Sustainability (Switzerland) is the most dominant source with NP = 5 documents, and it has an h-index = 5, g-index = 5, and total citations (TC) of 121, with the first publication year (PY_start) in 2020. The m-index value of 0.714 indicates a relatively high and consistent citation impact during the observation period. Next, Journal of Urban Management contains 2 documents with h-index = 2, g-index = 2, total citations of 18, and an m-index of 0.500 since 2023. Meanwhile, several other journals each contribute one document, including Cleaner Logistics and Supply Chain (TC = 25; m-index = 0.200; PY_start 2022), Computers, Environment and Urban Systems (TC = 31; m-index = 0.250; PY_start 2023), Energy and Buildings (TC = 1; m-index = 0.500; PY_start 2025), Environment and Behavior (TC = 49; m-index = 0.167; PY_start 2021), Environment, Development and Sustainability (TC = 10; m-index = 0.333; PY_start 2024), Environmental Earth Sciences (TC = 21; m-index = 0.125; PY_start 2019), European Transport Research Review (TC = 28; m-index = 0.100; PY_start 2017), and Globalization and Health (TC = 4; m-index = 0.100; PY_start 2017). Overall, although most journals contribute only one document, there are significant differences in total citations and m-index values. This indicates that the scientific influence of each source is determined not only by the number of publications but also by citation impact and the length of time since the initial publication.

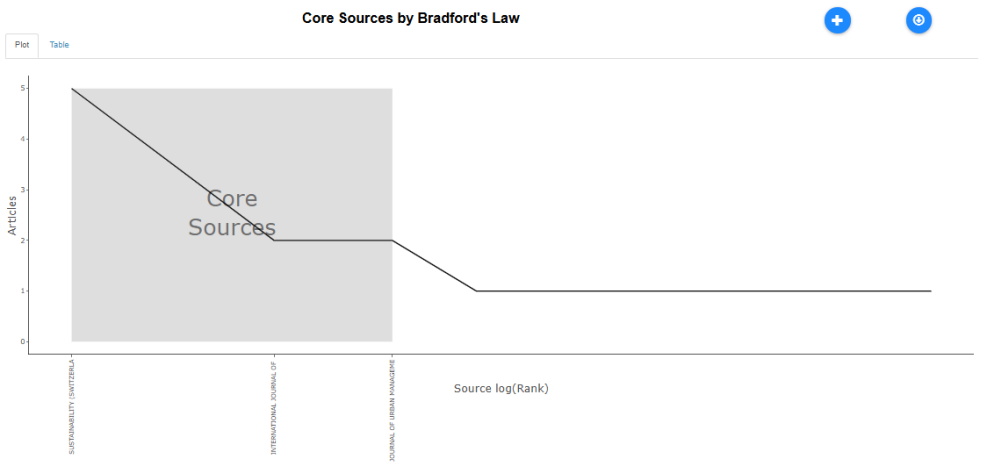



**Figure 8**. Core Sources by Bradford'd Law.

Based on the principle of Bradford's Law, the graph shows the presence of a core zone consisting of journals with the highest number of publications in the dataset. Within this core zone, Sustainability (Switzerland) occupies the top position with approximately 5 articles, followed by International Journal of Advanced Computer Science and Journal of Urban Management, each with about 2 articles. These three journals represent the most productive sources and form the central distribution of literature on the analyzed topic. Outside the core zone, the number of articles per source decreases to around one article per journal, indicating that most publications are dispersed across many sources with smaller contributions. This pattern aligns with Bradford's Law, where a small number of journals contribute a relatively large proportion of articles, while the remaining publications are distributed across numerous peripheral journals. Therefore, this visualization confirms that although the research is multidisciplinary and spread across various sources, several core journals serve as the main publication centers within the field of study.

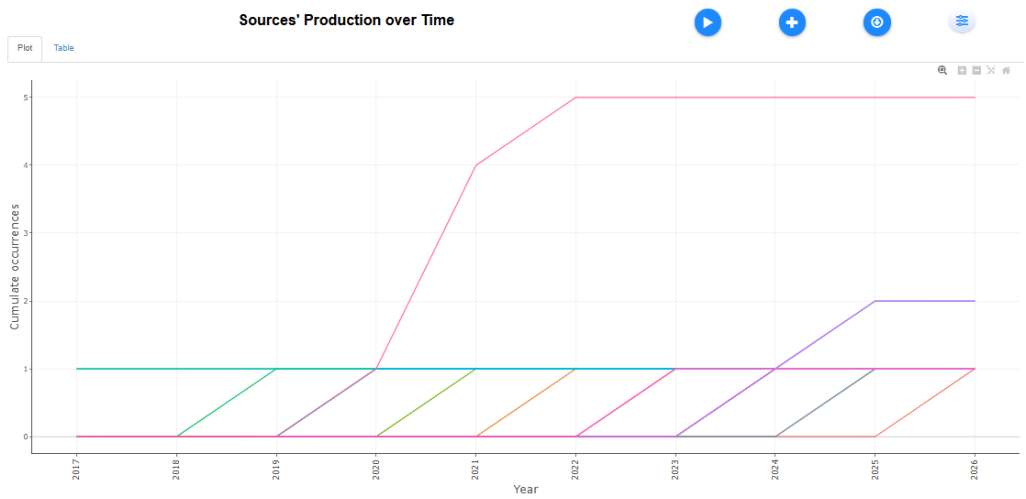



**Figure 9**. Cumulate Occurrences.

The Sources' Production over Time graph illustrates the cumulative growth of publications from each journal during the 2017–2026 period. The X-axis represents the publication year, while the Y-axis shows the cumulative number of article occurrences for each source. It can be observed that Sustainability (Switzerland) demonstrates the most significant growth, with a sharp increase beginning in 2020 and reaching a cumulative total of 5 articles by 2022, after which it remains relatively stable until 2026. Meanwhile, Journal of Urban Management shows a gradual increase, reaching a total of 2 articles in 2025. Several other journals—including Cleaner Logistics and Supply Chain, Computers, Environment and Urban Systems, Energy and Buildings, Environment and Behavior, Environment, Development and Sustainability, Environmental Earth Sciences, European Transport Research Review, and Globalization and Health—display more gradual patterns, each

reaching a cumulative total of 1 article in different publication years. Overall, the visualization indicates that the most consistent and dominant publication growth originates from a single primary journal, while other sources contribute sporadically and are dispersed across the observation period.

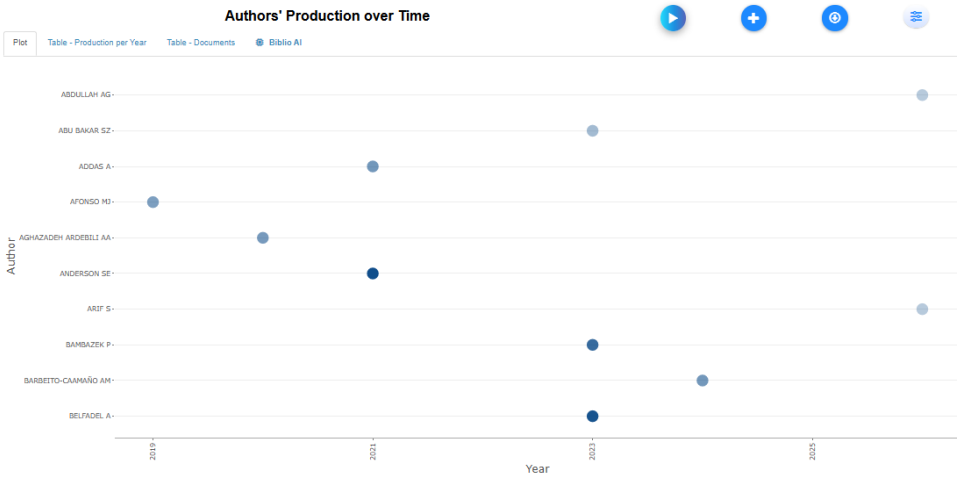



**Figure 10**. Authors Production Over Time.

The Authors' Production over Time graph presents author productivity based on publication year. The Y-axis lists the authors' names, such as ABDULLAH AG., ABU BAKAR SZ., ADDAS A., AFONSO MI., AGHAZADEH ARDEBILI AA., ANDERSON SE., ARIF S., BAMBAZEK P., BARRETO-CAMAÑO AM., and BELFADEL A., while the X-axis shows the publication years appearing in the dataset: 2019, 2021, 2023, and 2025. The visualization uses bubble/scatter points to represent each author's contribution in a specific year. Each point indicates that the corresponding author published an article in that particular year. The distribution of points demonstrates that authors' publication activities occurred between 2019 and 2025, with several authors contributing in different years. Overall, this graph maps individual author contributions to scientific publications based on temporal distribution and reveals the productivity patterns of each author within the observed period.

**Table 5.** Top 10 Countries' Scientific Production.

| Country | Freq |
|---|---|
| China | 5 |
| Indonesia | 5 |
| Malaysia | 5 |
| Usa | 5 |
| Brazil | 4 |
| Portugal | 4 |
| Netherlands | 3 |
| Thailan | 3 |
| Uk | 3 |
| France | 2 |

The table presents the distribution of publication frequency by country along with the corresponding number of publications (Freq). Based on the data, China, Indonesia, Malaysia, and the USA each have 5 publications, placing them at the highest position in the table. Below them, Brazil and Portugal each record 4 publications. Furthermore, the Netherlands, Thailand, and the UK each contribute 3 publications, while France has the lowest number with 2 publications. These data indicate that publication contributions are relatively evenly distributed among several countries, with China, Indonesia, Malaysia, and the USA emerging as the leading contributors. The participation of other countries is also notable, although their publication counts are slightly lower compared to the top group.

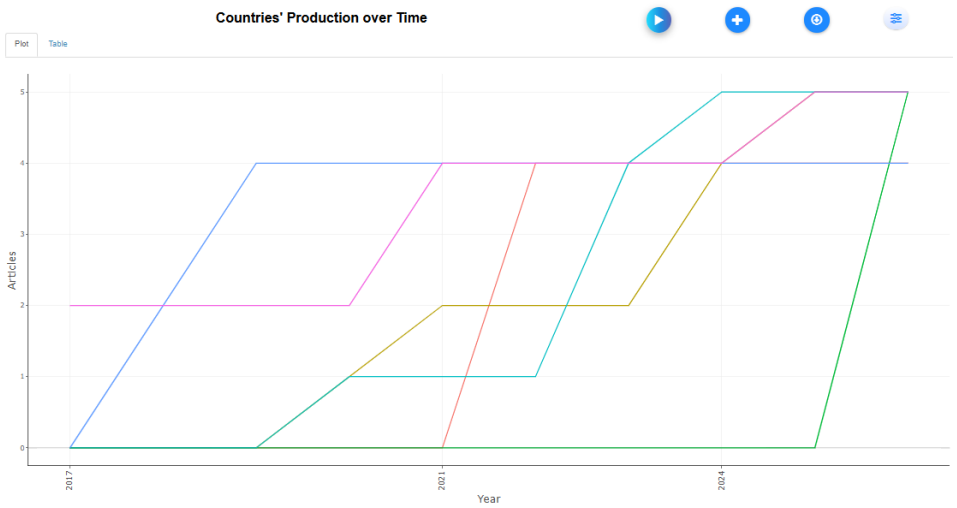



**Figure 11.** Countries' Production over Time

The graph entitled “Countries' Production over Time” illustrates the trend of scientific article production across several countries from 2017 to 2025. The X-axis represents the publication years (2017, 2019, 2021, 2023, and 2025), while the Y-axis shows the number of articles, ranging from 0 to 5. Based on the visible trend lines, several countries demonstrate a gradual increase in publication output over time. At the beginning of the period (2017), most countries recorded either 0 or 2 articles. Moving into 2019 and 2021, an upward trend is observed, with some countries reaching up to 4 articles. During the 2023–2025 period, certain countries show further growth, reaching as many as 5 articles, while others remain relatively stable at around 4 articles. Overall, the graph indicates a general upward trend in article production over time, with most countries experiencing notable growth particularly toward 2023–2025. This visualization effectively facilitates comparison of scientific productivity development among countries within the observed timeframe.

**Overlay visualization.**

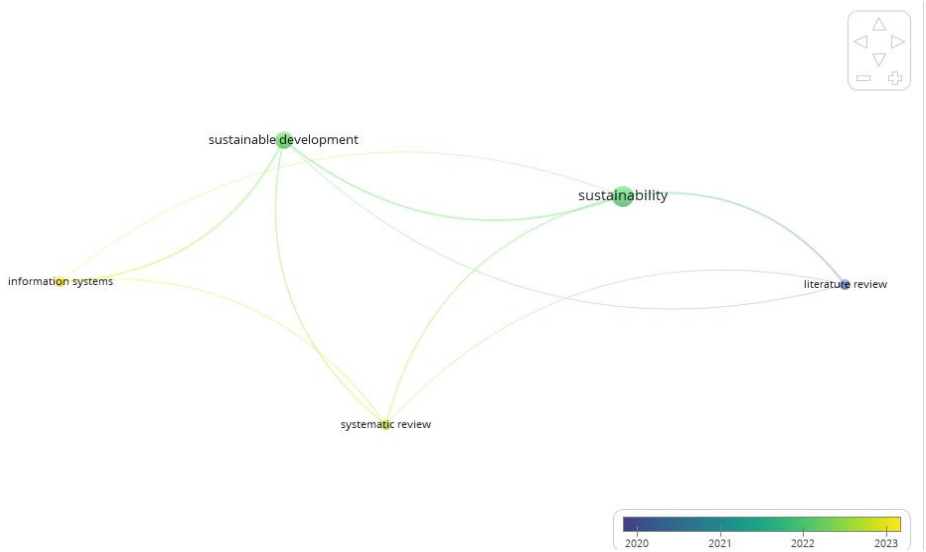



**Figure 12**. Network visualization.

The figure presents a network visualization of interconnected keywords within the research field. The visible keywords include sustainable development, sustainability, systematic review, literature review, and information systems. Each term is represented as a node (point), while the connecting lines indicate relationships or co-occurrence among keywords within scientific publications. Larger nodes such as sustainable development and sustainability indicate higher dominance or more frequent occurrence in the dataset. The colors of nodes and links follow a temporal gradient (shown in the legend ranging from 2020 to 2023), representing the average year of keyword appearance. Bluish tones correspond to earlier years (around 2020), whereas green to yellow tones represent more recent years (closer to 2023). Overall, the visualization shows that sustainability and sustainable development act as central research themes, strongly associated with systematic review and literature review approaches, and also linked to information systems. This indicates that during the 2020–2023 period, research predominantly focused on literature-based studies of sustainability, particularly within the context of information systems.

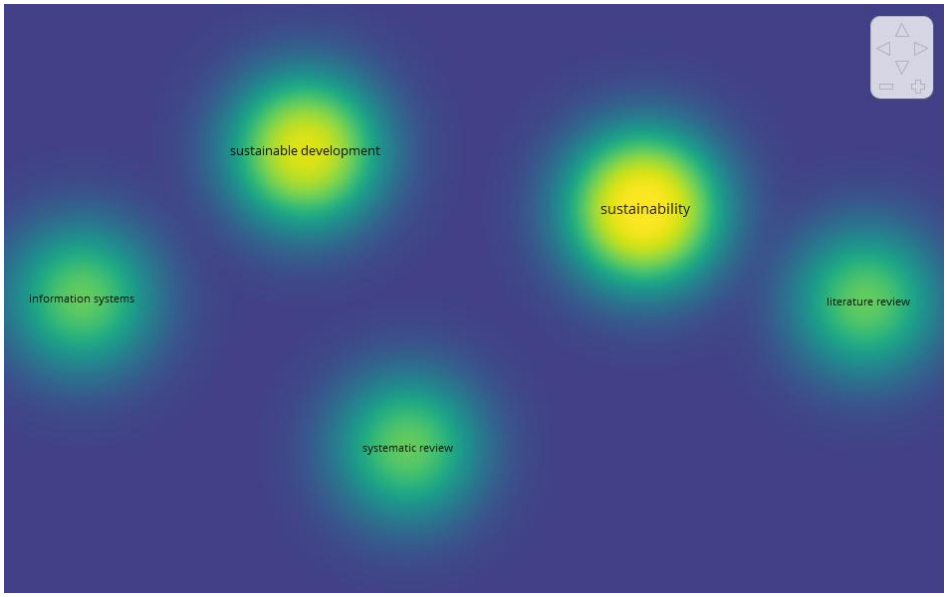



**Figure 13**. Density Visualization.

The figure presents a density map visualization that illustrates the frequency and dominance of keywords within a collection of scientific publications. In this map, color represents intensity: bright

yellow areas indicate keywords with the highest frequency of occurrence, green areas reflect moderate frequency, and the blue–purple background represents low-density regions. The brighter the color surrounding a term, the greater its contribution or prominence within the research landscape. In the visualization, the keyword "sustainability" appears as the most dominant term, positioned within the brightest and widest area, indicating that it serves as the central focus of the analyzed publications. The term "sustainable development" also demonstrates a high level of density, although slightly lower than "sustainability." This suggests that both concepts are closely interconnected and form the primary foundation of the reviewed research. Meanwhile, terms such as "systematic review," "literature review," and "information systems" are also present on the map but with comparatively lower density levels. The presence of "systematic review" and "literature review" indicates that many studies employ structured literature-based approaches to examine sustainability issues. The appearance of "information systems" highlights the linkage between sustainability topics and the information systems domain, though not as the main focus. Overall, the density map demonstrates that the overarching research theme is strongly centered on sustainability and sustainable development, supported by literature-based methodologies and integrated with information systems perspectives. This visualization provides a comprehensive understanding of topic structure, research priorities, and areas receiving the greatest attention during the analyzed period.

**SLR Review**

From the 25 retrieved records, the analysis focuses on the entire dataset consisting exclusively of documents classified as articles.

**Table 6.** SLR Study Data

| No | Type | count |
|---|---|---|
| 1 | Article | 25 |

**Prisma Method Results**

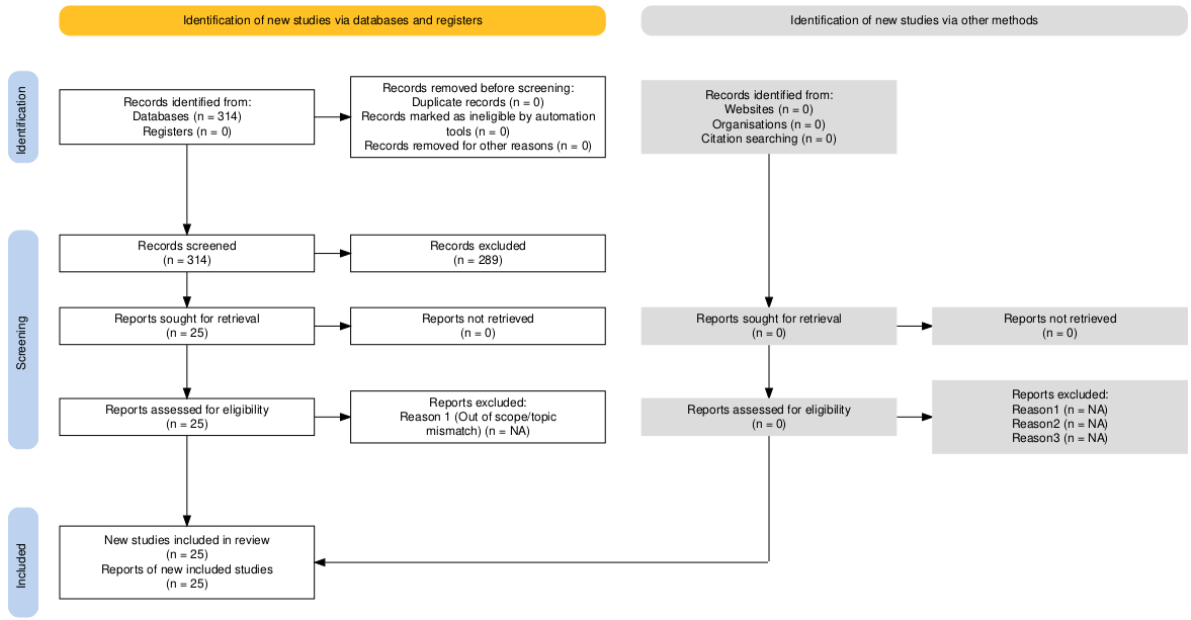



**Figure 14**. Prisma Method Result Diagram.

The flow diagram represents a PRISMA chart illustrating the identification and selection process of studies in the systematic literature review. The process began with the identification stage, where 314 records were retrieved from the database, and no records were obtained from registers. At this initial stage, no duplicate records were found, no studies were removed by automation tools, and no records were excluded for other reasons. Therefore, all 314 records proceeded to the screening

phase. During the screening stage, the 314 records were reviewed based on titles and abstracts. As a result, 289 records were excluded, leaving 25 reports to be assessed in full-text form. All 25 full-text reports were successfully retrieved and evaluated in the eligibility stage. After assessing their relevance and compliance with the inclusion criteria, all 25 reports were deemed eligible and included in the review. Thus, the final stage resulted in 25 new studies being incorporated into the systematic review. Meanwhile, searches conducted through other methods such as websites, organizations, or citation tracking did not yield any additional records. Overall, the diagram demonstrates that all studies included in the final assessment originated from the database search and successfully met the predefined inclusion criteria.

**Table 7**. Main Classifications in the Elicit AI Methodology.

| Main Classification | Included Sub-Methods | count | Percentage |
|---|---|---|---|
| Systematic Review-Based Research | Systematic Literature Review (SLR), Systematic Review, SLR + Bibliometric Analysis | 19 | 76% |
| Mixed Methods Research | Qualitative and quantitative combination | 2 | 8% |
| Quantitative Research | Statistical analysis/quantitative approach | 1 | 4% |
| Unspecified / Descriptive | The methodology is not explicitly explained. | 3 | 12% |
| Total | | 25 | 100% |

The table presents the distribution of research methodologies employed in the 25 analyzed articles. The Systematic Review–Based Research approach clearly dominates, accounting for 19 articles (76%). This category includes Systematic Literature Review (SLR), general Systematic Review, and SLR combined with bibliometric analysis. The prevalence of this approach indicates that most studies aim to synthesize, organize, and evaluate existing knowledge rather than generate primary empirical data. Such dominance reflects a strong emphasis on consolidating theoretical foundations, identifying research trends, and mapping the development of the field. Furthermore, the Mixed Methods Research approach appears in 2 articles (8%). These studies integrate qualitative and quantitative techniques within a single research design, enabling a more comprehensive understanding of the investigated topic. By combining numerical data analysis with interpretative exploration, mixed methods research provides balanced insights, although its presence in the dataset remains limited. The Quantitative Research approach is identified in only 1 article (4%), focusing on statistical analysis or numerical measurement. This very small proportion suggests that empirical testing and hypothesis-driven measurement are not yet widely implemented within the examined literature. Meanwhile, the Unspecified/Descriptive category includes 3 articles (12%), indicating that several studies do not explicitly describe their methodological framework. Overall, the findings reveal that the reviewed corpus is heavily dominated by systematic review–oriented studies, while empirical investigations remain relatively scarce. This pattern demonstrates that the current body of literature is more oriented toward synthesizing and mapping prior research rather than conducting direct field data collection or experimental validation.

**Table 8**. Main Classification in Main findings Ecilit AI.

| Classification of Main Findings | General Description of Findings | count | Percentage |
|---|---|---|---|
| Effectiveness / Positive Impact | Demonstrate significant improvement in learning outcomes, performance, efficiency, or benefits | 11 | 44% |
| Effectiveness / Positive Impact | Identify implementation barriers, biases, system limitations, or ethical issues | 6 | 24% |
| Trend Analysis and Research Mapping | Mapping research developments, dominant themes, and research gaps | 5 | 20% |
| Development Recommendations / Framework | Proposing a new model, strategy, or conceptual framework | 3 | 12% |

| Classification of Main Findings | General Description of Findings | count | Percentage |
|---|---|---|---|
| Total | | 25 | 100% |

Based on the table, the research findings are dominated by the Effectiveness/Positive Impact category, comprising 11 articles (44%). Studies in this category generally report improvements in learning outcomes, performance, efficiency, or significant benefits resulting from the implementation of the investigated concepts or technologies. This indicates that a substantial portion of the literature emphasizes demonstrating the practical value and measurable advantages of sustainability-related systems or approaches. The second largest category is Identification of Challenges/Limitations, which includes 6 articles (24%). Findings in this group focus on implementation barriers, potential biases, system limitations, and ethical concerns arising from practical application. This reflects an awareness among researchers of the complexities and constraints associated with adopting sustainability-oriented technologies and systems. The Trend Analysis and Research Mapping category accounts for 5 articles (20%), highlighting studies that concentrate on mapping research developments, identifying dominant themes, and uncovering existing research gaps. These works contribute to a broader understanding of the field's evolution and future directions. Finally, Development Recommendations/Framework Proposals represent the smallest category, with 3 articles (12%). These studies primarily propose new models, strategies, or conceptual frameworks aimed at advancing the field. Overall, this distribution suggests that most studies within the analyzed corpus focus on validating effectiveness or positive impacts, while also maintaining attention to challenges, research gaps, and future development directions.

**Table 9.** Main Classifications in Summary Elicit AI.

| Summary Classification | Summary Content Focus | count | Percentage |
|---|---|---|---|
| Conceptual and Theoretical Synthesis | The summary contains an explanation of the main concepts, theories and framework of thought. | 9 | 36% |
| Effectiveness and Impact of Implementation | The summary emphasizes the results, benefits, or impact of the implementation. | 7 | 28% |
| Analysis of Challenges and Limitations | The summary discusses barriers, risks, or ethical issues. | 5 | 20% |
| Recommendations and Directions for Further Research | The summary contains suggestions for future development or research agendas. | 4 | 16% |
| Total | | 25 | 100% |

Based on the table, the majority of research summaries fall into the Conceptual and Theoretical Synthesis category, comprising 9 articles (36%). Summaries in this category generally describe key concepts, theoretical foundations, and principal frameworks that underpin the studies. This indicates that many publications aim to clarify fundamental ideas and provide structured understanding before empirical application. The second largest category is Effectiveness and Implementation Impact, with 7 articles (28%). These summaries emphasize results, benefits, and the influence of applying the studied concepts or technologies. Such findings demonstrate the practical relevance of the research and highlight measurable outcomes derived from implementation. The Analysis of Challenges and Limitations category includes 5 articles (20%), discussing barriers, risks, and ethical considerations associated with real-world application. This suggests that researchers not only evaluate success but also critically assess constraints that may affect sustainability or system adoption. Meanwhile, Recommendations and Future Research Directions account for 4 articles (16%), focusing on development suggestions and proposed research agendas. These studies contribute by guiding future investigations and identifying opportunities for improvement. Overall, these findings indicate that the research summaries in the analyzed corpus are not solely oriented toward presenting theoretical concepts. They also emphasize evaluation of implementation, identification of challenges, and directions for future research development, reflecting a balanced approach between theory and practice.

**Table 10**. Main Classification in Elicit AI Study Design

| Study Design Classification | Characteristics of Research Design | count | Percentage |
|---|---|---|---|
| Systematic Review Design | Systematic review design with literature search and selection protocol | 19 | 76% |
| Mixed Methods Design | Combination of qualitative and quantitative designs in one study | 2 | 8% |
| Quantitative Design | Design based on collection and analysis of numerical data | 1 | 4% |
| Descriptive / Not Specified Design | The research design is not described in detail. | 3 | 12% |
| Total | | 25 | 100% |

Based on the table, the systematic review design is the most dominant approach, accounting for 19 studies (76%). This indicates that the majority of research focuses on comprehensive literature analysis using structured search protocols and selection procedures to synthesize and evaluate previous findings. The strong dominance of this design reflects a field that prioritizes consolidating existing knowledge, identifying patterns, and mapping theoretical developments rather than conducting primary empirical investigations. The mixed methods design ranks second, representing 2 studies (8%). This approach combines qualitative and quantitative techniques within a single study, allowing for a more comprehensive and multidimensional analysis. Although limited in number, these studies demonstrate efforts to integrate numerical data with interpretative insights to strengthen research validity. Meanwhile, the descriptive or unspecified design accounts for 3 studies (12%), indicating that some publications do not clearly detail their methodological framework. This lack of explicit methodological explanation may affect transparency and replicability. The quantitative design is the least utilized approach, with only 1 study (4%). This very small proportion suggests that research involving direct empirical data collection and statistical analysis remains relatively limited in this field. Overall, these findings imply that the domain is still largely dominated by literature-based studies, while empirical research involving direct data collection and statistical examination remains underrepresented and offers significant opportunities for future development.

**Table 11**. Main Classifications in the Future Research Elicit AI

| Classification of Further Research Directions | Recommendation Focus | count | Percentage |
|---|---|---|---|
| Development of Empirical Studies | Experimental research, field studies, or direct model testing is required. | 10 | 40% |
| Expansion of Research Variables/Context | Testing on different populations, levels, or contexts | 6 | 24% |
| New Model/Framework Development | Refinement or development of the conceptual framework | 5 | 20% |
| Deepening Ethical and Policy Aspects | Review of regulation, bias, data security, and policy implications | 4 | 16% |
| Total | | 25 | 100% |

Based on the table, future research directions are predominantly focused on the development of empirical studies, accounting for 10 studies (40%). This indicates a strong need for experimental research, field studies, and direct model testing to ensure that findings are not merely conceptual but also practically validated. The emphasis on empirical validation reflects a growing awareness that theoretical synthesis alone is insufficient without real-world application and measurable evidence. The second most prominent direction is the expansion of variables or research contexts, representing 6 studies (24%). This focus involves testing models or concepts across different populations, educational levels, sectors, or settings to enhance the generalizability and robustness of research findings. Such expansion contributes to broader applicability and strengthens external

validity. The development of new models or frameworks ranks next, comprising 5 studies (20%). This suggests the importance of refining and innovating conceptual frameworks to ensure they remain adaptive, comprehensive, and aligned with evolving research needs and technological advancements. Finally, the deepening of ethical and policy aspects accounts for 4 studies (16%). Although this category has the smallest proportion, it remains highly significant, as it addresses regulatory considerations, data security, governance issues, and broader policy implications arising from research implementation. Overall, the distribution highlights a clear shift toward strengthening empirical validation, expanding contextual applications, refining conceptual frameworks, and ensuring ethical and policy alignment in future research agendas.

## Discussion

### Interpretation of Key Findings

The findings from this systematic literature review reveal several critical insights regarding the current state of research on software and information systems for sustainability. First, the dominance of the systematic review approach (76%) indicates that this field is still in a consolidative phase, where researchers prioritize the synthesis of existing knowledge over generating primary empirical evidence. This pattern suggests that sustainable software engineering is still in the process of establishing its theoretical foundations and conceptual boundaries, a characteristic of an emerging interdisciplinary field. The heavy reliance on literature reviews, while valuable for mapping the research landscape, also signifies a maturity gap where empirical validation has not kept pace with conceptual development. Further bibliometric analysis shows that Sustainability (Switzerland) serves as the primary publication outlet, contributing 5 of the 25 articles analyzed, with a total of 121 citations and an h-index of 5. This concentration indicates that the journal has become a central forum for discourse on sustainability-related software research. However, the multidisciplinary distribution across 19 different sources confirms that this topic transcends traditional disciplinary boundaries. The engagement of journals covering urban management, energy systems, and environmental behavior underscores the cross-sectoral relevance of software and information systems in sustainability initiatives. Geographically, the equal contributions from China, Indonesia, Malaysia, and the United States (each with 5 publications) reveal an interesting dynamic. While the United States represents an established research tradition in software engineering, the strong presence of Southeast Asian countries particularly Indonesia and Malaysia suggests that sustainability-focused software research is gaining significant traction in developing regions where environmental pressures from rapid digitalization and urbanization are most acute. This geographical distribution aligns with earlier observations by Wasif et al., (2022) regarding the critical role of Green ICT in developing countries. Thematic analysis through keyword co-occurrence and density visualization identified "sustainability" and "sustainable development" as the main conceptual anchors, closely linked with "information systems," "systematic review," and "literature review." This configuration confirms that the literature largely frames sustainability within the context of information systems while maintaining a methodological orientation towards literature synthesis. Notably absent from this dense core are terms related to specific technical implementation, programming paradigms, or phases of the software development lifecycle, suggesting that the field has not yet fully engaged with the technical details of sustainable software engineering.

### Comparison with Previous Reviews

The findings of this study both confirm and extend previous review efforts in sustainable software engineering. Swacha, (2022), in a scoping review of sustainable software models, identified similar fragmentation in the literature but did not extensively address application domains or evaluation metrics a gap that this review partially fills by incorporating these dimensions. This study confirms Swacha's observation that the field lacks unified frameworks, while further revealing that this fragmentation persists despite research activity in the intervening years. Compared to the systematic mapping study by Barišić et al., (2025) on cyber-physical systems, which focused narrowly on modeling approaches, this review adopts a broader lens encompassing information systems more generally. The convergence in both studies' findings noting the dominance of conceptual work over empirical validation suggests that the gap between theoretical frameworks and practical

implementation is a systemic issue across sustainability-oriented computing research, rather than one confined to specific subdomains. The identification of information systems as a central thematic node aligns with Corbett et al., (2020), who positioned artificial intelligence and data management as key enablers of sustainability. However, while Corbett's work emphasized technological opportunities, this review reveals that the literature has yet to translate these opportunities into empirically validated implementations. Similarly, Rashid et al., (2021) proposed the Green-Agile Maturity Model as an evaluation framework, but the limited presence of quantitative research (only 4%) in the current dataset suggests that such models remain largely untested in real-world contexts. The finding that 44% of studies reported positive impacts or effectiveness aligns with the generally optimistic tone in the literature, as reflected in Akoh Atadoga et al., (2024) and Sriraman & Raghunathan, (2023). However, the substantial proportion of studies identifying challenges and limitations (24%) indicates that researchers are increasingly acknowledging the complexities of implementing sustainable practices a more balanced perspective than previous reviews that tended toward uncritical advocacy of green software approaches.

**Emerging Trends and Patterns**

Several emerging trends can be discerned from this analysis. First, there is a clear trajectory towards interdisciplinary integration. The Three-Field Plot analysis reveals linkages between sustainability research and domains such as urban planning, geographic information systems (GIS), and charging station infrastructure. This pattern indicates that software sustainability is increasingly being contextualized within broader socio-technical systems rather than treated as an isolated technical concern. The integration with GIS and spatial planning, in particular, suggests that location-aware and context-sensitive sustainability solutions are gaining traction. Second, temporal keyword analysis shows a shift from broad sustainability discourse toward more structured methodological approaches. The prominence of "systematic review" and "literature review" in recent years (2020–2023) indicates that the field is becoming methodologically mature, with researchers adopting rigorous synthesis techniques to consolidate evolving knowledge. This methodological maturation is a prerequisite for the subsequent phase of empirical testing and validation. Third, the future research directions identified in the analysis particularly the calls for empirical studies (40%) and expansion of research contexts (24%) signal an impending transition from conceptual consolidation to empirical investigation. This anticipated shift responds to critiques raised by Nazir et al., (2020) regarding the lack of integrated models and echoes the recommendations of Ahmad Ibrahim et al., (2022) for more grounded, practice-oriented research. The relatively low emphasis on ethical and policy aspects (16%) in future research agendas is somewhat concerning, given the growing recognition of data governance, algorithmic bias, and digital equity as critical sustainability issues (Trang, 2021; Ghouri et al., (2024). Fourth, the publication pattern reveals a potential "consolidation phase" followed by a "diversification phase." The publication peak during 2025 (5 articles) followed by a sharp decline in 2026 (1 article) may indicate that the field has reached a saturation point in terms of literature-based studies and is now poised for a new wave of empirical research. If this interpretation holds, future reviews should anticipate a larger proportion of quantitative studies, case reports, and action research in the coming years. Finally, the international collaboration rate of 36% suggests that sustainable software research is becoming increasingly globalized, with researchers from different regions combining expertise. This collaborative trend is essential for addressing sustainability challenges that transcend national boundaries and for ensuring that solutions are culturally appropriate and contextually relevant across diverse settings. In summary, this discussion confirms that while the field of software and information systems for sustainability has made significant strides in conceptual development and literature synthesis, it stands at a critical juncture where empirical validation, contextual expansion, and ethical integration must take center stage. The foundation laid by systematic reviews now needs to be reinforced through rigorous field studies, model testing, and policy engagement to translate theoretical promise into tangible sustainability outcomes.

Implications:

This study offers several theoretical implications by reinforcing the position of sustainable software and sustainable information systems as multidisciplinary fields still in the phase of conceptual

consolidation, as demonstrated by the dominance of systematic review-based studies focused on synthesizing models, conceptual frameworks, and evaluation approaches rather than empirical testing. Through the integration of Systematic Literature Review and bibliometric analysis, this research maps the intellectual structure of the field and affirms that software sustainability encompasses environmental, social, and economic dimensions, while simultaneously identifying a theoretical gap: the absence of operational and tested standards for evaluation metrics. Practically, these findings provide guidance for developers to apply design for sustainability principles from the earliest stages of development through resource efficiency and the integration of sustainability indicators into quality assurance processes. For organizations, the findings highlight the importance of positioning sustainable information systems as long-term operational strategies through green IT governance and digital transformation initiatives. For policymakers, the results inform the development of standards, regulations, and incentives that encourage the adoption of sustainable software practices. Ultimately, this study underscores that the sustainability of software systems is not merely a technical concern but requires the simultaneous integration of technological, managerial, and policy dimensions.

Research Contribution:

This study makes a primary contribution through the development of an integrated classification framework that unifies various approaches in the study of sustainable software and information systems into a systematic and easily comprehensible structure. This framework connects conceptual models, application domains, and evaluation metrics, thereby providing a comprehensive mapping of how sustainability concepts have been applied and measured in previous research. Through the model–application–metric mapping, this study demonstrates the interconnections between theoretical approaches and practical implementations, while also identifying inconsistencies in the still-diverse use of sustainability indicators. Furthermore, this research successfully identifies research gaps, particularly the lack of empirical validation, the absence of uniform evaluation metric standards, and the limited integration between technical, organizational, and policy aspects. Thus, this study not only synthesizes the development of the literature but also provides clear direction for the advancement of future research toward more measurable and applicable implementations of sustainable information systems.

Limitations:

This study has several limitations that should be considered when interpreting its results. First, there is a potential for publication bias, as the articles reviewed were drawn exclusively from indexed databases and publications. Consequently, studies reporting negative results, non-indexed studies, or industry reports are likely not captured in this analysis. This may affect the comprehensive representation of the research landscape in sustainable software and information systems. Second, the majority of the studies reviewed remain conceptual in nature and are based on systematic reviews, resulting in limited empirical validation of sustainability models, frameworks, and metrics. This condition constrains the study's ability to draw robust conclusions regarding the effectiveness of real-world implementations. Therefore, the findings of this review should be understood as a conceptual and structural mapping that requires further strengthening through future empirical studies.

## Suggestions:

Based on the analysis results indicating the dominance of conceptual approaches and systematic reviews (76%) along with the continued scarcity of empirical studies, future research needs to be directed toward the development of AI-driven sustainability systems capable of integrating data analytics, prediction, and intelligent decision-making within the context of sustainable software and information systems. Furthermore, the development of standardized sustainability metrics is necessary to enable consistent, measurable, and comparable evaluations of system performance across studies and sectors. Such standardization is essential for strengthening empirical validity and enhancing the reliability of measuring environmental, social, and economic impacts. Moreover, research should also promote the development of cross-domain sustainability platforms that can integrate various sectors such as urban planning, energy, IoT, and information systems within a

unified framework, thereby reducing research fragmentation and generating more comprehensive, applicable solutions relevant to real-world implementation needs.

## CONCLUSION

Based on the systematic literature review presented in the article, it can be concluded that the field of software and information systems for sustainability is characterized by a consolidative phase focused on theoretical synthesis, with a significant dominance of systematic review-based studies (76%) that prioritize mapping conceptual models and evaluation approaches over empirical validation. The bibliometric analysis reveals that while the topic is multidisciplinary and geographically diverse with major contributions from both developed countries and emerging economies like Indonesia and Malaysia the research remains fragmented and centered on sustainability and sustainable development as core themes, often linked to information systems and literature review methodologies. A critical finding is the notable gap between conceptual frameworks and their practical application, as evidenced by the scarcity of quantitative and mixed-methods research (only 12% combined) and the absence of standardized evaluation metrics. The study concludes that to advance the field, future research must shift towards empirical validation, develop AI-driven sustainability systems, establish uniform measurement standards, and create integrated cross-domain platforms, thereby bridging the gap between theoretical promise and tangible, real-world sustainability outcomes.

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## AUTHOR CONTRIBUTION STATEMENT

The contributions of each author to this research are as follows: XX was responsible for the overall research process, including conceptualization, data collection and analysis (SLR and bibliometric analysis), and preparation of the initial manuscript draft. XX contributed to supervision, methodology validation, as well as manuscript review and editing. XX provided input during the design stage and analysis of research findings. All authors have approved the final version of the manuscript for publication

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